RVP7 V21 Release Notes

These notes cover changes made to the RVP7 code since release V20 of 2 January 2001. If you are upgrading from an earlier release, please read those notes also.

Bug Repairs

1. A bug was repaired in the Dual-PRF unfolding algorithm that would sometimes cause incorrect velocities to be output when stationary targets were being observed. The error could be seen when carefully selected test signals were injected into the RVP7, but the problem would rarely affect real weather and clutter echoes. This bug is nearly a decade old; it has been present in all RVP7 and RVP6 code releases to date.

2. A minor bug was repaired in the implementation of trigger period quantization from the **Mt** menu. The calculation was not rounding properly when the *offset* term was nonzero.

3. Independent "H" and "V" noise levels are now shown in the **Mt<n>** menu for single receiver systems that are alternate-on-receive. Previously only the "H" level was shown, even though both levels were correctly being measured independently. Note that single receiver systems that are alternate-on-transmit will still show only one receiver noise level, because there is truly only one receiver.

New Features

1. An alternate form of the SETPWF command is now available that allows an array of *N* (up to 64) trigger periods to be specified, and also gives much finer time resolution in the choice of each period. The XARGS command is first used to load an array of *N* 32-bit words that define the trigger period(s) in nanoseconds. The RVP7 will then generate triggers whose shapes (relative starts and widths) are identical for each pulse, but whose periods follow the selected sequence. Trigger patterns such as these are intended to support research customers who use the real-time (I,Q) data stream directly.

2. A change has been made in the thresholding of dBZ and dBT reflectivity data, making it more meaningful to include an SQI test in the computation of these parameters. The SQI comparison value for qualifying reflectivity data will now be the secondary SQI threshold that is defined via a slope and offset from the primary user value (see **Mf** command). This secondary threshold is more permissive (lower valued), and has traditionally been used to qualify LOG data only in the Random Phase processing mode. With this change, the secondary SQI threshold is applied uniformly in all processing modes whenever reflectivity data are specified as being thresholded by SQI.

   You now have more freedom in applying an SQI threshold to your LOG data, because the cutoff value for reflectivity can be chosen independently from the cutoff value for the other Doppler parameters. In the past, the SQI test would not normally be applied to LOG data because of the so-called "black hole" problem, i.e., loss of LOG data within regions of high shear, even though the reflectivity itself was strong. You may now experiment with applying an SQI threshold to help cleanup the LOG data, but without introducing any significant black holes.

3. The RVP7 now has the ability to track the power-weighted center-of-mass of the burst pulse, and to automatically shift the trigger timing so that the pulse remains in the center of the burst analysis window of the **Pb** plot. This means that external sources of drift in the timing of the transmitted pulse (temperature, aging, etc.) will be tracked and nulled out during normal operation; so that fixed targets will remain fixed in range, and clean Tx phase measurements will always be available on every pulse.

   The Burst Pulse Tracker feedback loop makes changes to the trigger timing in response to the measured position of the burst. Timing changes will generally be made only when the RVP7 is not actively acquiring data, in the same way that AFC feedback is held off for similar "quiet" times. However, if the center-of-mass has drifted more than 1/3 the width of the burst analysis window, then the timing adjustment will be made right away. Also, there will be an approximately 5ms interruption in the normal trigger sequence whenever any timing changes are made.

   When you first upgrade to V21 the Burst Pulse Tracker will be enabled by default, and will begin running in the background to keep your burst pulse centered. If you do not want to use the tracker, then please disable it in the **Mb** menu. The tracker defaults to *ON* after an upgrade because it is likely that many customers may not realize that their Tx pulse has indeed drifted from the time it was originally configured.

4. The Burst Pulse Tracker and AFC feedback loop are each fine-tuning servos that keep the burst pulse "centered" in time and frequency. These servos have been expanded to include a combined "Hunt Mode" that will track down a missing burst pulse when we are uncertain of both its time and frequency. This coarse-tuning mode is especially valuable for initializing the two fine-tuning servos in radar systems that drift significantly with time and temperature.

   When the radar transmitter is *On* but the burst pulse is missing, it may be because either of the following have happened:

   - It is misplaced in time, i.e., the Tx pulse is outside of the window displayed in the **Pb** plotting command. In this case, the trigger timing needs to be changed in order to bring the center of the pulse back to the center of the window.
   - It is mistuned in frequency, i.e., the AFC feedback is incorrect and has caused the burst frequency to fall outside of the passband of the RVP7 antialias filters. In this case the AFC (or DAFC) needs to be changed so that proper tuning is restored.

   The new Hunt Mode performs a 2-dimensional search in time and frequency to locate the burst; searching across a $\pm$20μsec time window, and across the entire AFC span. If a valid Tx pulse (i.e., meeting the minimum power requirement) can be found anywhere within those intervals then the Burst Pulse Tracker and AFC loops will be initialized with the time and frequency values that were discovered. The fine servos then commence running with a good burst signal starting from those initial points.

Depending on how the hunting process has been configured in the **Mb** menu, the whole procedure may take several seconds to complete. The RVP7's host computer interface remains completely functional during this time, but any acquired data would certainly be questionable. GPARM status bits in word #55 indicate when the hunt procedure is running, and whether it has completed successfully. A new opcode allows the host computer to initiate Hunt Mode when it knows or can sense that a burst pulse should be present (See Section 6.27 of the *RVP7 User's Manual*). The IRIS/INGEST process has been modified to issue this command at the start of each task for which the radar is known to be transmitting.

5. You now have explicit control over which RVP7 trigger outputs are timed relative to the transmitter pre-fire sequence, versus those which are relative to the actual received target ranges. Triggers in the first category will be moved left/right by the "L/R" keys in the **Pb** plot, and will also be slewed in response to Burst Pulse Tracking. Triggers in the second category remain fixed relative to "receiver range zero", and are not affected by the "L/R" keys or by tracking. Previously, all triggers fell into the first category.

   It is very helpful to have these two categories of trigger start times. Triggers that fire the transmitter, either directly or indirectly, should all be moved as a group when hunting for the burst pulse and moving it to the center of the FIR window. However, triggers that function as range strobes should be fixed relative to range zero, i.e., the center of that window, and the center of the burst. This distinction becomes important when the transmitter's pre-fire delay drifts with time and temperature. See also Setup Change #6.

6. Improvements have been made to the AFC debugging mode that was introduced in V20 as part of the **Ps** plot command. The previous walking-ones test is still available; but now it is also possible to setup any fixed bit pattern on the digital AFC control lines. This is very useful when testing a new STALO hookup since you can toggle each control bit and verify that the correct frequencies are obtained.

   The AFC test mode is entered from the **Ps** menu by typing the "|" key. The following list of keybindings will be shown, and will remain in effect until the test mode is exited by typing "Q".

```
AFC Test Mode Subcommands
      W      Use Walking–Ones pattern
      P      Toggle Pin/Bit numbering
   0–9,A–O   Toggle AFC Bits 0–24 (Pins 1–25)
               2 2 2 2 2 1 1 1 1 1 1 1 1 1 1
               4 3 2 1 0 9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0
               – – – – – – – – – – – – – – – – – – – – – – – – –
               O N M L K J I H G F E D C B A 9 8 7 6 5 4 3 2 1 0
```

   The **Ps** command continues to run normally during the AFC test mode. The customary AFC information will be replaced with a hexadecimal readout of the present 25-bit value. Your live display may look something like:

```
Navg:3,  FIR:1.33 usec (48 Taps),  BW:1.000 MHz,  DC–Gain:ZERO
Freq:26.610 MHz,  Pwr:–64.6 dBm,  AFC–Test:0000207F (Bits)
```

Initially, the walking-ones test will be running and the AFC bits will be cycling approximately once per second. The walking-ones test is handy as an oscilloscope diagnostic, and you may return to it at any time by typing “W”.

Typing any of the characters “0” through “9” or “A” through “O” will enter a new mode in which a static 25-bit digital AFC pattern is controlled directly. Each key toggles its corresponding bit, as summarized in the keybindings printout. Any 25-bit pattern can be made by toggling the appropriate bits (initially all zero) to one. Within any particular pattern, it is also easy to toggle a particular bit On/Off in order to verify its function.

The “P” command lets you decide whether the 25-bit word represents a numeric AFC span that is mapped into pins via the pin-map table in the **Mb** menu; or whether it represents those pins directly. The printed hex test value will be followed either by “(Bits)” or “(Pins)” accordingly. When in “Pins” mode, the “0” key toggles Pin-1, the “1” key toggles Pin-2, etc. When in “Bits” mode, the “0” key toggles whatever pin or pins have been designated to be driven from Bit-0 of the numeric AFC. The “Pins” mode is useful when you are doing the initial electrical tests of the wiring of each pin. After the pin wiring has been verified and the **Mb** mapping table has been created, then the “Bits” mode allows you to test the complete digital AFC interface.

7. The LSIMUL (Load Simulated Time Series) opcode has been modified slightly so that “I” and “Q” values greater than 12-bits are handled properly, i.e., as samples that are over the top of the assumed numerical range, but not distorted in any way. The IRIS **ascope** utility also has been modified not to clip very strong simulated values that might happen to overflow. The result is that you can now dial up and mix strong simulated signals in **ascope** without worrying about numerical overflows.

8. It is now possible to merge user trigger waveforms together to create more complex trigger signals. See Setup Change #1.

9. Multiplicative scale factors can now be applied to the incoming TAG angles for azimuth and elevation. See Setup Change #7.

10. A small but important change has been made in the algorithm for producing the six user trigger waveforms. The change only applies when a) the trigger period is internally determined, i.e., the external pretrigger input is not being used, and b) the overall span of the six trigger definitions combined does not fit into that period. Previously, the period would be altered so that all waveforms would fit; but now, any waveforms that do not fit are zeroed (not output) so that the desired period is preserved. This means that you can now define triggers with large positive start times, and they will pop into existence only when the PRF is low enough to accommodate them.

    For example, if Trigger #2 is defined as a 200.0μsec pulse starting at +400.0μsec, then that trigger would be suppressed if the PRF were 2000Hz, but it would be present at a PRF of 1000Hz. Whenever a trigger does not completely fit within the overall period it is suppressed entirely. Thus, even though the +400.0μsec start time is still valid at 2000Hz, the entire 200.0μsec pulse would not fit, and so the pulse is eliminated altogether.

11. The error reporting by the **V** command of the powerup memory diagnostic tests in the slave DSPs has been improved. All chips that fail will now be reported, rather than just reporting a summary.

12. New opcodes have been added which allow the host computer to set the AFC level and Burst Pulse tracking slew. The present value of tracking slew can also be read back in GPARM word #56. These new interfaces make it possible for the host computer to be much smarter in setting initial trigger timing and AFC levels for radar systems that drift significantly with time and temperature. See Sections 6.25 and 6.26 of the *RVP7 User's Manual* for details.

13. An additional immediate status word has been added as GPARM output word #55. The new bits indicate

    Bit-0 : Burst pulse time adjustments can be made
    Bit-1 : Burst pulse frequency adjustments can be made
    Bit-2 : Burst pulse hunting is enabled
    Bit-3 : Burst pulse hunt is running right now
    Bit-4 : Last burst pulse hunt was unsuccessful

Setup Changes

1. Seven new questions have been added to the **Mt** (Triggers and Timing) menu to allow you to merge the six user triggers together. The resulting trigger patterns can therefore be much more complex than before. The questions are:

```
Merge triggers to create composite waveforms: YES
  Merge Trigger #1 into : #1:  #2:  #3:  #4:  #5:  #6:
  Merge Trigger #2 into : #1:  #2:  #3:  #4:  #5:  #6:
  Merge Trigger #3 into : #1:Y #2:  #3:  #4:  #5:  #6:
  Merge Trigger #4 into : #1:  #2:Y #3:  #4:  #5:  #6:
  Merge Trigger #5 into : #1:  #2:Y #3:  #4:  #5:  #6:
  Merge Trigger #6 into : #1:  #2:  #3:  #4:  #5:  #6:
```

   In this example, Trigger #3 will be merged into Trigger #1; Trigger #3 will be unaltered, and Trigger #1 will be the "OR" of itself with Trigger #3. Likewise, Triggers #4 and #5 will be merged into Trigger #2 so that the later will contain three distinct pulses within each PRT. Answer each question with a sequence of up to six "Y" or "N" responses in order to set the merged destinations for each trigger line.

   Note that the six triggers are still defined in the usual way in the **Mt<n>** menu, i.e., start time, width, etc. The only change is that you may now combine these individual pulse definitions into a more complex composite output waveform. An example of why you might want to do this is given in Example #1.

2. The question *Replace triggers with alternate waveforms* has been added to the **Mt** setup menu. Answering "No" will suppress the six subsequent questions that define how each trigger is optionally remapped. This helps reduce menu sprawl since "No" is the most common answer. When you upgrade to V21 the appropriate answer will automatically be filled in depending on whether any alternate waveforms had previously been setup.

3. The new question *Enable Burst Pulse Tracking* has been added to the **Mb** setup menu in support of New Feature #3. Remarkably, for such an intricate new feature, there are no additional parameters to configure. The characteristic settling times for the burst are already defined elsewhere in the same menu, and the tracking algorithm uses dynamic thresholds to control the feedback. If you decide to use the tracker, be sure to check for appropriate answers to the new trigger attributes question described in Setup Change #6.

4. New questions have been added to the **Mb** menu to configure the Burst Pulse Hunt Mode described in New Feature #4.

```
Enable Time/Freq hunt for missing burst: YES
  Number of frequency intervals to search: 5
  Settling time for each frequency hop: 0.25 sec
  Automatically hunt immediately after being reset: YES
    Repeat the hunt every: 60.00 sec
```

The trigger timing interval that is checked during Hunt Mode is always the maximum ±20μsec; hence no further setup questions are needed to define the hunting process in time. The hunt in frequency is a different matter. The overall frequency range will always be the full –100% to +100% AFC span; but the number of subintervals to check must be specified, along with the STALO settling time after making each AFC change. With the default values shown, AFC levels of –66%, –33%, 0%, +33%, and +66% will be tried, with a one-quarter second wait time before checking for a valid burst at each AFC setting.

You should choose the number of AFC intervals so that the hunt procedure can deduce an initial AFC level that is within a few megaHertz of the correct value. The normal AFC loop will then take over from there to keep the radar in tune. For example, if your radar drifts considerably in frequency so that the AFC range had to be as large as 35MHz, then choosing fifteen subintervals might be a good choice. The hunt procedure would then be able to get within 2.3MHz of the correct AFC level. The settling time can usually be fairly short, unless you have a STALO that wobbles for a while after making a frequency change. Note that hunting in frequency is not allowed for Motor/Integrator AFC loops, and the two AFC questions will be suppressed in that case.

The RVP7 can optionally begin hunting for a missing burst pulse immediately after being reset, but before any activity has been detected from the host computer. This might be useful in systems that both drift a lot and generally have their transmitter *On*. However, this option is really included just as a workaround; the correct way for a burst pulse hunt to occur is via an explicit request from the host computer which “knows” when the pulse really should be present. Blindly hunting in the absence of that knowledge can not be done because there are many reasons why the burst pulse may legitimately be missing, e.g., during a radar calibration.

5. New features have been added to the **Pb** plotting command to assist with the Burst Pulse Tracker and Hunt Mode (See New Features #3. and #4.).

   - The center-of-mass of the burst pulse is shown as a tick mark within the data window of plotted samples. This marker (added in V20) moves left and right to follow the mean power point of the burst. What's new in this release is that a second "error bar" is now drawn surrounding the tick mark to indicate the uncertainty of the mark itself. This error interval is used by the tracking algorithm to decide when a timing change can be made with confidence.

- The TTY status line now shows the present value of timing slew (measured in microseconds) being applied to track the burst, e.g., as *BPT:–1.34* . The slew will be zero initially when the RVP7 is first powered up, meaning that the normal trigger start times are all being used.
- New subcommands "b" and "B" have been added to temporarily disable or re-enable the Burst Pulse Tracker. The tracker must be disabled in order for the L/R keys to be used to shift the nominal trigger timing. The "b" key disables tracking and sets the trigger slew to zero; the "B" key re-enables tracking starting from that zero value.
- The new "+" subcommand initiates a hunt for the burst pulse. Progress messages are printed as successive AFC values are tried, and the trigger slew and AFC level are set according to where the pulse was found. If no burst pulse can be found, then the previous trigger slew and AFC are not changed.

6. A new question has been added to the Mt menu to specify which triggers are Tx-relative and which are Rx-relative (See New Feature #5.).

```
Rx–Fixed Triggers: #1:  #2:  #3:  #4:  #5:  #6:  P0:  P1:  Z:
```

Answer with a sequence of "Y" or "N" responses for each of the six trigger lines, for the two polarization control lines, and for the timing of the phase control lines. You should answer *No* for any trigger that is involved with the pre-fire timing of the transmitter. When you first upgrade to V21 all triggers will be set to *No* since that has always been the default behavior. However, if you enable the new Burst Pulse Tracker, you will probably want to assign a *Yes* to some of your triggers so that they remain fixed relative to the burst itself.

7. The two 16-bit TAG angle inputs can now be scaled by arbitrary multipliers. The TAG setup questions in the **Mp** menu now read:

```
TAG Bits to invert     AZ:0000    EL:0000
TAG scale factors      AZ:1.0000  EL:1.0000
TAG offsets (degrees)  AZ:0.00    EL:0.00
```

The overall operations are performed in the order listed. Incoming bits are first inverted according to the two 16-bit XOR masks. This yields an unsigned 16-bit integer value which is then multiplied by the signed scale factor. The result is interpreted as a 16-bit binary angle (in the low sixteen bits), to which the offset angle is finally added.

As an example, suppose that the elevation angle input to the RVP7 was in an awkward form such as unsigned integer tenths of degrees, i.e., 0x0000 for zero degrees, 0x000a for one degree, 0x0e06 for minus one degree, etc. If we apply a scale factor of 65536/3600 = 18.2044 to these units, we will get 16-bit binary angles in the standard format. If we further suppose that the input angle rotated “backwards”, we could take care of this too using a multiplier of –18.2044.

Examples

1. The following unusual trigger waveforms can be generated by taking advantage of New Features #8. and #10. Suppose that we need to generate an 835.0μsec continuous periodic trigger on Trigger #1. This waveform must be constant and uninterrupted. However, Trigger #2 will be the actual transmitter trigger and will operate at periods of 1x, 2x, and 3x this basic interval. The constant trigger should always occur 5.0μsec after the transmitter trigger, and the RVP7/IFD sampling crystal is 36.000MHz. We use the following setups from **Mt**:

```
Quantize trigger PRT to ((180 x AQ) + 0) clocks
Merge Trigger #1 into : #1:  #2:  #3:  #4:  #5:  #6:
Merge Trigger #2 into : #1:  #2:  #3:  #4:  #5:  #6:
Merge Trigger #3 into : #1:Y #2:  #3:  #4:  #5:  #6:
Merge Trigger #4 into : #1:Y #2:  #3:  #4:  #5:  #6:
Merge Trigger #5 into : #1:  #2:  #3:  #4:  #5:  #6:
Merge Trigger #6 into : #1:  #2:  #3:  #4:  #5:  #6:
```

And from **Mt0**:

```
Trigger #1 – Start:    0.00 usec
        #1 – Width:    1.00 usec     High:YES
Trigger #2 – Start:   –5.00 usec
        #2 – Width:    1.00 usec     High:YES
Trigger #3 – Start:  835.00 usec
        #3 – Width:    1.00 usec     High:YES
Trigger #4 – Start: 1670.00 usec
        #4 – Width:    1.00 usec     High:YES
```

The trigger period will be quantized to multiples of 5.0μsec (180 cycles at 36MHz). This is necessary because the IRIS and ASCOPE interfaces for specifying PRF are restricted to integer values in Hertz. From IRIS or ASCOPE you could request a fixed PRF of 1198Hz, fixed PRF of 599Hz, or 3:2 unfolding at 599Hz. Trigger #1 will then include the additional pulse contributions from Triggers #3 and #4, placed at multiples of 835.0μsec, and present whenever each individual pulse period allows them to fit. The net result is that Trigger #1 becomes a continuous uninterrupted pulse train in all three operating modes.